

PULSED FLOW FOR CAPACITY CONTROL

BACKGROUND OF THE INVENTION

In a closed air conditioning or refrigeration system there are a number of methods of unloading that can be employed. Commonly assigned U.S. Pat. No. 4,938,666 discloses unloading one cylinder of a bank by gas bypass and unloading an entire bank by suction cutoff. Commonly assigned U.S. Pat. No. 4,938,029 discloses the unloading of an entire stage of a compressor and the use of an economizer. Commonly assigned U.S. Pat. No. 4,878,818 discloses the use of a valved common port to provide communication with suction for unloading or with discharge for V_i control, where V_i is the discharge pressure to suction pressure ratio. In employing these various methods, the valve structure is normally fully open, fully closed, or the degree of valve opening is modulated so as to remain at a certain fixed position. One problem associated with these arrangements is that capacity can only be controlled in steps or expensive motor driven modulation valves must be employed to fix the valve opening at a certain position for capacity control.

SUMMARY OF THE INVENTION

Gradual compressor capacity can be achieved by rapidly cycling solenoid valve(s) between fully open and fully closed positions. The cycling solenoid valve(s) can be located in the compressor suction line, the compressor economizer line and/or the compressor bypass line which connects the economizer line to the suction line. The percentage of time that a valve is open determines the degree of modulation being achieved. However, because the cycling time is so much shorter than the response time of the system, it is as though the valve(s) are partially opened rather than being cycled between their open and closed positions.

It is an object of this invention to provide continuous capacity control.

It is another object of this invention to provide step control in capacity modulation.

It is a further object of this invention to provide a less expensive alternative to the use of variable speed compressors.

It is another object of this invention to provide a less expensive alternative to a modulation valve. These objects, and others as will become apparent hereinafter, are accomplished by the present invention.

Basically, gradual or step control in capacity modulation of a refrigeration circuit is achieved by rapidly cycling a solenoid valve in the compressor suction line and/or the compressor economizer line and/or bypass line.

BRIEF DESCRIPTION OF THE DRAWING

For a fuller understanding of the present invention, reference should now be made to the following detailed description thereof taken in conjunction with the accompanying drawing wherein.

The FIGURE is a schematic representation of an economized refrigeration or air conditioning system employing the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the FIGURE, the numeral 12 generally designates a hermetic compressor in a closed refrigeration or air conditioning system 10. Starting with compressor 12, the system

10 serially includes discharge line 14, condenser 16, line 18, expansion device 20, evaporator 22, and suction line 24 completing the circuit. Line 18-1 branches off from line 18 and contains expansion device 30 and connects with compressor 12 via port 12-1 at a location corresponding to an intermediate point in the compression process. Economizer heat exchanger 40 is located such that line 18-1, downstream of expansion device 30, and line 18, upstream of expansion device 20, are in heat exchange relationship. The expansion devices 20 and 30 are labeled as electronic expansion devices, EEV, and are illustrated as connected to microprocessor 100. In the case of expansion device 20, at least, it need not be an EEV and might, for example, be a thermal expansion device, TEV. What has been described so far is generally conventional. The present invention provides bypass line 50 connecting lines 18-1 and 24 downstream of economizer heat exchanger 40 and evaporator 22, respectively, and places solenoid valve 52 in line 50, solenoid valve 54 in line 24 downstream of evaporator 22 and upstream of line 50 and solenoid valve 56 in line 18-1 downstream of economizer heat exchanger 40 and upstream of line 50. Solenoid valves 52, 54, and 56 and EEV30 are all controlled by microprocessor 100 responsive to zone inputs. Where expansion device 20 is, as illustrated, an EEV, it also is controlled by microprocessor 100.

In "normal" operation of system 10, valves 52 and 56 are closed and hot high pressure refrigerant gas from compressor 12 is supplied via line 14 to condenser 16 where the refrigerant gas condenses to a liquid which is supplied via line 18 and idle economizer heat exchanger 40 to EEV20. EEV20 causes a pressure drop and partial flashing of the liquid refrigerant passing therethrough. The liquid-vapor mixture of refrigerant is supplied to evaporator 22 where the liquid refrigerant evaporates to cool the required space and the resultant gaseous refrigerant is supplied to compressor 12 via suction line 24 containing solenoid valve 54 to complete the cycle.

The operation described above is conventional and capacity is controlled through EEV20. Pursuant to the teachings 40 of the present invention solenoid valve 54 can be rapidly pulsed to control the capacity of compressor 12. Since the pulsing will be more rapid than the response time of the system 10, the system 10 responds as though the valve 54 is partially open rather than being cycled between its open and closed positions. Modulation is achieved by controlling the percentage of the time that valve 54 is on and off. To prevent a vacuum pump operation, the "off" position of valve 54 may need to permit a limited flow.

To increase capacity of system 10, economizer heat 50 exchanger 40 is employed. In economizer heat exchanger 40, lines 18 and 18-1 are in heat exchange relationship. Solenoid valve 56 is open and solenoid valve 52 closed and a portion of the liquid refrigerant in line 18 is directed into line 18-1 where EEV30 causes a pressure drop and a partial 55 flashing of the liquid refrigerant. The low pressure liquid refrigerant passes into economizer heat exchanger 40 where the refrigerant in line 18-1 extracts heat from the refrigerant in line 18 causing it to cool further and thereby provide an increased cooling effect in evaporator 22. The refrigerant in 60 line 18-1 passing through economizer heat exchanger 40 is supplied to compressor 12 via port 12-1 under the control of valve 56 which is, in turn, controlled by microprocessor 100. Line 18-1 delivers refrigerant gas to a trapped volume at an intermediate stage of compression in the compressor 12, as 65 is conventional. However, according to the teachings of the present invention the economizer flow in line 18-1 and, as such, system capacity is controlled by rapidly cycling valve

Terms in Claims	Supporting Language in the Specification
Claim 4. (NEW) An air conditioning or refrigeration system comprising: a compressor having a refrigeration fluid suction port and a refrigeration fluid discharge port; and a valve in fluid communication with the compressor, the valve being operative to cycle with a cycling time shorter than the response time of the system to modulate compressor capacity.	Abstract; Fig. 1 See compressor 12 in Fig. 1; Column 1, line 66; Column 2, line 5; Column 2, line 27; Column 2, line 64, etc.
Claim 5. (NEW) The air conditioning or refrigeration system of claim 4 further comprising a capacity controller operative to generate a control signal corresponding to desired capacity modulation and operatively connected to the valve to send capacity control signals to cycle the valve with a cycling time shorter than the response time of the system to modulate compressor capacity.	Abstract; Fig. 1; Column 1, lines 26-30; Column 2, lines 26-48 Column 1, lines 32-35; Column 2, lines 41-45
Claim 6. (NEW) The air conditioning or refrigeration system of claim 4 wherein the valve is cycled between a fully open and a fully closed position.	Column 1, lines 25-27
Claim 7. (NEW) The air conditioning or refrigeration system of claim 5 wherein the controller comprises a microprocessor.	See microprocessor controller 100 in Fig 1; Column 2, lines 22-23

Table I

Terms in Claims**Supporting Language in the Specification**

Claim 8. (NEW) The air conditioning or refrigeration system of claim 4 wherein the valve is a solenoid valve.	Column 1, lines 25-27
Claim 9. (NEW) An air conditioning or refrigeration system comprising: a compressor	See compressor 12 in Fig. 1; Column 1, line 66; Column 2, line 5; Column 2, line 27; Column 2, line 64, etc. Abstract; Fig. 1
having a refrigeration fluid suction port and a refrigeration fluid discharge port, being operative to compress refrigeration fluid received via the suction port and discharged via the discharge port;	Abstract; Fig. 1; Column 1, lines 26-30; Column 2, lines 1-3; Column 2, line 59 to Column 3, line 9
a refrigerant flow line operative to carry refrigeration fluid and in fluid communication with the compressor;	Fig. 1; Column 1, line 65 to Column 2, line 25
a capacity controller operative to generate a control signal corresponding to desired capacity modulation; and	Abstract; Fig. 1; Column 1, lines 26-30; Column 2, lines 1-3
a valve in the refrigerant flow line which is operatively connected to the controller to receive capacity control signals from the controller and	See microprocessor controller 100 in Fig. 1; Column 2, line 22-23
operative in response to capacity control signals received from the controller to cycle with a cycling time shorter than the response time of the system to modulate compressor capacity.	Abstract; Fig. 1; Column 1, line 26-30; Column 2, lines 26-48 Column 1, lines 32-35; Column 2, lines 41-45

Table I

Table I

<u>Terms in Claims</u>	<u>Supporting Language in the Specification</u>
Claim 10. (NEW) The system of claim 9 wherein the valve is cycled between a fully open position and a fully closed position.	Column 1, lines 25-27
Claim 11. (NEW) The system of claim 9 wherein the system capacity controller comprises a microprocessor.	See microprocessor controller 100 in Fig 1; Column 2, lines 22-23
Claim 12. (NEW) The system of claim 9 wherein the valve is a solenoid valve.	Column 1, lines 25-27
Claim 13. (NEW) The system of claim 10 wherein the valve in the fully closed position permits a limited fluid flow through the refrigerant flow line.	Column 2, lines 46-48

Terms in Claims

Supporting Language in the Specification	
Claim 14. (NEW) An air conditioning or refrigeration system comprising:	Abstract; Fig. 1
a compressor	See compressor 12 in Fig. 1; Column 1, line 56; Column 2, line 5; Column 2, line 27; Column 2, line 64, etc
having a refrigeration fluid suction port	Abstract; Fig 1; Column 1, lines 26-30; Column 2, lines 1-3; Column 2, line 59 to Column 3, line 9
and a refrigeration fluid discharge port,	Abstract; Fig 1; Column 1, lines 26-30; Column 2, lines 1-3; Column 2, line 59 to Column 3, line 9
being operative to compress refrigeration fluid received via the suction port and discharged via the discharge port;	Fig. 1; Column 1, line 65 to Column 2, line 25
a refrigerant flow line operative to carry refrigeration fluid and in fluid communication with the compressor;	See Abstract; Fig 1; Column 1, lines 26-30; Column 2, lines 1-3
a capacity controller operative to generate a control signal corresponding to desired capacity modulation; and	See microprocessor controller 100 in Fig 1; Column 2, lines 22-23
a solenoid valve in the refrigerant flow line	Abstract; Fig. 1; Column 1, lines 26-30; Column 2, lines 26-48
which is operatively connected to the controller to receive capacity control signals from the controller and	See connecting lines shown in Fig. 1 between microprocessor controller 100 and the valve, e.g. valve 52, valve 54, and/or valve 56
operative in response to capacity control signals received from the controller to cycle between a fully open position and a fully closed position to modulate compressor capacity.	Column 1, lines 25-27

Table I

Table I

Terms in Claims	Supporting Language in the Specification
Claim 15. (NEW) The system of claim 14 wherein the system capacity controller comprises a microprocessor.	See microprocessor controller 100 in Fig 1; Column 2, lines 22-23
Claim 16. (NEW) The system of claim 14 wherein the solenoid valve in the fully closed position permits a limited fluid flow through the refrigerant flow line.	Column 2, lines 46-48

Table I

Terms in Claims	Supporting Language in the Specification
Claim 17. (NEW) A capacity modulated compressor for an air conditioning or refrigeration system having a refrigerant flow line, comprising: a compressor housing comprising a compression chamber,	Abstract; Fig. 1; Summary See compressor 12 in Fig. 1; Column 1, line 66; Column 2, line 5; Column 2, line 27; Column 2, line 64, etc.
at least one refrigerant injection port operative to pass refrigerant to the compression chamber, and	Abstract; Fig 1; Column 1, lines 26-30; Column 2, lines 1-3; Column 2, line 59 to Column 3, line 9
at least one refrigerant discharge port operative to pass compressed refrigerant from the compression chamber;	Abstract; Fig 1; Column 1, lines 26-30; Column 2, lines 1-3; Column 2, line 59 to Column 3, line 9
a capacity controller operative to generate a control signal corresponding to desired capacity modulation; and	See microprocessor controller 100 in Fig 1; Column 2, lines 22-23
a valve operatively connected to the controller to receive capacity control signals from the controller and	Abstract; Fig. 1; Column 1, lines 26-30; Column 2, lines 22-48
operative in response to capacity control signals received from the controller to cycle with a cycling time shorter than the response time of the system to modulate compressor capacity.	Column 1, lines 32-35; Column 2, lines 41-45

Terms in Claims

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Claim 18. (NEW) The compressor of claim 17 wherein the valve is cycled between a fully closed position and a fully open position.	Column 1, lines 25-27
Claim 19. (NEW) The compressor of claim 17 wherein the valve is disposed in a refrigerant flow line upstream with respect to refrigerant flow to said at least one refrigerant injection port.	Fig. 1; Column 2, lines 6-25
Claim 20. (NEW) The compressor of claim 17 wherein the valve is mounted to the compressor housing at the refrigerant injection port.	See Abstract; Fig. 1, Column 1, lines 27-30
Claim 21. (NEW) The compressor of claim 17 wherein the system capacity controller comprises a microprocessor.	See microprocessor controller 100 in Fig 1; Column 2, lines 22-23

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Table I

<u>Terms in Claims</u>	<u>Supporting Language in the Specification</u>
Claim 22. (NEW) The compressor of claim 17 wherein the valve is a solenoid valve.	Column 1, lines 25-27
Claim 23. (NEW) The compressor of claim 18 wherein the valve in the fully closed position permits a limited fluid flow through the refrigerant flow line.	Column 2, lines 46-48

Terms in Claims

Supporting Language in the Specification

Claim 24. (NEW) A capacity modulated compressor for an air conditioning or refrigeration system having a refrigerant flow line, comprising:	Abstract; Fig. 1; Summary
a compressor housing comprising a compression chamber,	Fig. 1; Column 1, line 66; Column 2, line 5; Column 2, line 27; Column 2, line 64, etc.
at least one refrigerant injection port operative to pass refrigerant to the compression chamber, and	Abstract; Fig 1; Column 1, lines 26-30; Column 2, lines 1-3; Column 2, line 59 to Column 3, line 9
at least one refrigerant discharge port operative to pass compressed refrigerant from the compression chamber;	Abstract; Fig 1; Column 1, lines 26-30; Column 2, lines 1-3; Column 2, line 59 to Column 3, line 9
a capacity controller operative to generate a control signal corresponding to desired capacity modulation; and	See microprocessor controller 100 in Fig 1; Column 2, lines 22-23
a solenoid valve operatively connected to the controller to receive capacity control signals from the controller and	Abstract; Fig. 1; Column 1, lines 26-30; Column 2, lines 26-48
operative in response to capacity control signals received from the controller to cycle between a fully open position and a fully closed position to modulate compressor capacity.	Column 1, lines 25-27

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Terms in Claims

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Claim 25. (NEW) The compressor of
claim 24

wherein the solenoid valve is disposed
in a refrigerant flow line upstream with
respect to refrigerant flow to said at
least one refrigerant injection port.

Claim 26. (NEW) The compressor of
claim 24

wherein the solenoid valve is mounted
to the compressor housing at the
refrigerant injection port.

Claim 27. (NEW) The compressor of
claim 24

wherein the system capacity controller
comprises a microprocessor.

Claim 28. (NEW) The compressor of
claim 24

wherein the solenoid valve in the fully
closed position permits a limited fluid
flow through the refrigerant flow line.

Abstract; Fig. 1; Summary

Abstract; Fig. 1; Summary

See microprocessor controller 100 in Fig 1;
Column 2, lines 22-23

Column 2, lines 46-48

Table I

Terms in Claims

Supporting Language in the Specification

Claim 29. (NEW) A capacity modulated compressor comprising:	Abstract; Fig. 1, Summary
a compressor having a suction inlet for supplying suction gas to the compressor;	See compressor 12 in Fig. 1; Column 1, line 66; Column 2, lines 1-5; Column 2, line 27; Column 2, line 64, etc.
a valve provided in the suction gas flow path to the compressor,	Abstract; Fig. 1; Column 1, lines 26-30; Column 2, lines 26-45
the valve being operable between open and closed positions to cyclically allow and prevent flow of suction gas into the compressor;	See Column 1, lines 33-35; Column 2, lines 44-45
a controller for actuating the valve between the open and closed positions,	See microprocessor controller 100 in Fig. 1; Column 2, lines 22-23
the controller being operative to cycle the valve such that its cycle time is shorter than the response time of the system to modulate compressor capacity.	Column 1, lines 32-35; Column 2, lines 41-45
Claim 30. (NEW) The capacity modulated compressor of claim 29 wherein the valve is positioned in close proximity to the compressor.	Abstract; Summary; Fig. 1

Table I

Terms in Claims

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Terms in Claims	Supporting Language in the Specification
Claim 31. (NEW) The capacity modulated compressor of claim 29 wherein the valve is a bidirectional valve.	Column 1, lines 25-27
Claim 32. (NEW) The capacity modulated compressor of claim 29 wherein the valve is a solenoid valve.	Column 1, lines 25-27

Table I

Table II

<u>Terms in Claims</u>	<u>Supporting Language in the Specification</u>
Claim 33. (NEW) A method of modulating the capacity of a compressor in an air conditioning or refrigeration system, comprising	Column 1, lines 32-33; Column 2, lines 41-45
cycling a valve, in fluid communication with the compressor, using a cycle time shorter than the response time of the system to modulate compressor capacity.	Fig. 1; Column 1, lines 32-35; Column 2, lines 41-45
Claim 34. (NEW) The method of claim 33 wherein the valve is a solenoid valve.	Column 1, lines 25-27
Claim 35. (NEW) A method of modulating the capacity of a compressor in a closed refrigerant circulating system, said compressor comprising a compression chamber having a port connected to a refrigerant line of the system through which refrigerant is supplied to the compression chamber, comprising:	Column 1, lines 32-33; Column 2, lines 41-45; Fig. 1
rapidly cycling a solenoid valve disposed in the refrigerant line upstream of said port between its fully open position and its fully closed position to modulate compressor capacity.	Fig. 1; Column 1, lines 25-27

Table II

Terms in Claims	Supporting Language in the Specification
Claim 36. (NEW) The method of claim 35 wherein rapidly cycling said solenoid valve comprises cycling the solenoid valve with a cycling time shorter than the response time of the system to modulate compressor capacity.	Fig. 1; Column 1, lines 25-27; Column 2, lines 38-45
Claim 37. (NEW) The method of claim 35 wherein said cycling controls the percentage of time said solenoid valve is fully open to refrigerant flow therethrough to the compression chamber.	Column 1, lines 32-35; Column 2, lines 41-45
Claim 38. (NEW) The method of claim 35 wherein said cycling is controlled by a microprocessor.	See microprocessor controller 100 in Fig 1; Column 2, lines 22-23

Terms in Claims

Terms in Claims	Supporting Language in the Specification
Claim 4. (NEW) An air conditioning or refrigeration system comprising:	Abstract; Fig. 1
a compressor having a refrigeration fluid suction port and a refrigeration fluid discharge port; and	See compressor 12 in Fig. 1; Column 1, line 66; Column 2, line 5; Column 2, line 27; Column 2, line 64, etc.
a valve in fluid communication with the compressor, the valve being operative to cycle with a cycling time shorter than the response time of the system to modulate compressor capacity	Abstract; Fig. 1; Column 1, lines 26-30; Column 2, lines 26-48 Column 1, lines 32-35; Column 2, lines 41-45
Claim 5. (NEW) The air conditioning or refrigeration system of claim 4 further comprising	See microprocessor controller 100 in Fig 1; Column 2, line 22-23
a capacity controller operative to generate a control signal corresponding to desired capacity modulation and operatively connected to the valve to send capacity control signals to cycle the valve with a cycling time shorter than the response time of the system to modulate compressor capacity.	Abstract; Fig. 1; Column 1, lines 26-30; Column 2, lines 26-48
Claim 6. (NEW) The air conditioning or refrigeration system of claim 4 wherein the valve is cycled between a fully open and a fully closed position.	Column 1, lines 25-27
Claim 7. (NEW) The air conditioning or refrigeration system of claim 5 wherein the controller comprises a microprocessor.	See microprocessor controller 100 in Fig 1; Column 2, lines 22-23

Table I

Terms in Claims

Supporting Language in the Specification

Claim 8. (NEW) The air conditioning or refrigeration system of claim 4 wherein the valve is a solenoid valve.	Column 1, lines 25-27
Claim 9. (NEW) An air conditioning or refrigeration system comprising:	Abstract; Fig. 1
a compressor	See compressor 12 in Fig. 1; Column 1, line 66; Column 2, line 5; Column 2, line 27; Column 2, line 64, etc.
having a refrigeration fluid suction port	Abstract; Fig 1; Column 1, lines 26-30; Column 2, lines 1-3; Column 2, line 59 to Column 3, line 9
and a refrigeration fluid discharge port,	Abstract; Fig 1; Column 1, lines 26-30; Column 2, lines 1-3; Column 2, line 59 to Column 3, line 9
being operative to compress refrigeration fluid received via the suction port and discharged via the discharge port;	Fig. 1; Column 1, line 65 to Column 2, line 25
a refrigerant flow line operative to carry refrigeration fluid and in fluid communication with the compressor;	Abstract; Fig 1; Column 1, lines 26-30; Column 2, lines 1-3
a capacity controller operative to generate a control signal corresponding to desired capacity modulation; and	See microprocessor controller 100 in Fig 1; Column 2, line 22-23
a valve in the refrigerant flow line which is operatively connected to the controller to receive capacity control signals from the controller and	Abstract; Fig. 1; Column 1, line 26-30; Column 2, lines 26-48
operative in response to capacity control signals received from the controller to cycle with a cycling time shorter than the response time of the system to modulate compressor capacity.	Column 1, lines 32-35; Column 2, lines 41-45

Table I

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<u>Terms in Claims</u>	<u>Supporting Language in the Specification</u>
Claim 10. (NEW) The system of claim 9 wherein the valve is cycled between a fully open position and a fully closed position.	Column 1, lines 25-27
Claim 11. (NEW) The system of claim 9 wherein the system capacity controller comprises a microprocessor.	See microprocessor controller 100 in Fig 1; Column 2, lines 22-23
Claim 12. (NEW) The system of claim 9 wherein the valve is a solenoid valve.	Column 1, lines 25-27
Claim 13. (NEW) The system of claim 10 wherein the valve in the fully closed position permits a limited fluid flow through the refrigerant flow line.	Column 2, lines 46-48

Terms in Claims

Supporting Language in the Specification

Claim 14. (NEW) An air conditioning or refrigeration system comprising: a compressor	Abstract; Fig. 1
having a refrigeration fluid suction port	See compressor 12 in Fig. 1; Column 1, line 66; Column 2, line 5; Column 2, line 27; Column 2, line 64, etc
and a refrigeration fluid discharge port,	Abstract; Fig 1; Column 1, lines 26-30; Column 2, lines 1-3; Column 2, line 59 to Column 3, line 9
being operative to compress refrigeration fluid received via the suction port and discharged via the discharge port;	Abstract; Fig 1; Column 1, lines 26-30; Column 2, lines 1-3; Column 2, line 59 to Column 3, line 9
a refrigerant flow line operative to carry refrigeration fluid and in fluid communication with the compressor;	Fig. 1; Column 1, line 65 to Column 2, line 25
a capacity controller operative to generate a control signal corresponding to desired capacity modulation; and	See Abstract; Fig 1; Column 1, lines 26-30; Column 2, lines 1-3 See microprocessor controller 100 in Fig 1; Column 2, lines 22-23
a solenoid valve in the refrigerant flow line which is operatively connected to the controller to receive capacity control signals from the controller and	Abstract; Fig. 1; Column 1, lines 26-30; Column 2, lines 26-48 See connecting lines shown in Fig. 1 between microprocessor controller 100 and the valve, e.g. valve 52, valve 54, and/or valve 56
operative in response to capacity control signals received from the controller to cycle between a fully open position and a fully closed position to modulate compressor capacity.	Column 1, lines 25-27

Table I

Table I

<u>Terms in Claims</u>	<u>Supporting Language in the Specification</u>
Claim 15. (NEW) The system of claim 14 wherein the system capacity controller comprises a microprocessor.	See microprocessor controller 100 in Fig 1; Column 2, lines 22-23
Claim 16. (NEW) The system of claim 14 wherein the solenoid valve in the fully closed position permits a limited fluid flow through the refrigerant flow line.	Column 2, lines 46-48

Terms in Claims

Supporting Language in the Specification

Claim 17. (NEW) A capacity modulated compressor for an air conditioning or refrigeration system having a refrigerant flow line, comprising:	Abstract; Fig. 1; Summary
a compressor housing comprising a compression chamber,	See compressor 12 in Fig. 1; Column 1, line 66; Column 2, line 5; Column 2, line 27; Column 2, line 64, etc.
at least one refrigerant injection port operative to pass refrigerant to the compression chamber, and	Abstract; Fig 1; Column 1, lines 26-30; Column 2, lines 1-3; Column 2, line 59 to Column 3, line 9
at least one refrigerant discharge port operative to pass compressed refrigerant from the compression chamber;	Abstract; Fig 1; Column 1, lines 26-30; Column 2, lines 1-3; Column 2, line 59 to Column 3, line 9
a capacity controller operative to generate a control signal corresponding to desired capacity modulation; and	See microprocessor controller 100 in Fig 1; Column 2, lines 22-23
a valve operatively connected to the controller to receive capacity control signals from the controller and	Abstract; Fig. 1; Column 1, lines 26-30; Column 2; lines 22-48
operative in response to capacity control signals received from the controller to cycle with a cycling time shorter than the response time of the system to modulate compressor capacity.	Column 1, lines 32-35; Column 2, lines 41-45

Table I

<u>Terms in Claims</u>	<u>Supporting Language in the Specification</u>
<p>Claim 18. (NEW) The compressor of claim 17 wherein the valve is cycled between a fully closed position and a fully open position.</p>	<p>Column 1, lines 25-27</p>
<p>Claim 19. (NEW) The compressor of claim 17 wherein the valve is disposed in a refrigerant flow line upstream with respect to refrigerant flow to said at least one refrigerant injection port.</p>	<p>Fig. 1; Column 2, lines 6-25</p>
<p>Claim 20. (NEW) The compressor of claim 17 wherein the valve is mounted to the compressor housing at the refrigerant injection port.</p>	<p>See Abstract; Fig. 1, Column 1, lines 27-30</p>
<p>Claim 21. (NEW) The compressor of claim 17 wherein the system capacity controller comprises a microprocessor.</p>	<p>See microprocessor controller 100 in Fig 1; Column 2, lines 22-23</p>

Table I

Table I

Terms in Claims	Supporting Language in the Specification
<p>Claim 22. (NEW) The compressor of claim 17 wherein the valve is a solenoid valve.</p>	<p>Column 1, lines 25-27</p>
<p>Claim 23. (NEW) The compressor of claim 18 wherein the valve in the fully closed position permits a limited fluid flow through the refrigerant flow line.</p>	<p>Column 2, lines 46-48</p>

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Terms in Claims	Supporting Language in the Specification
Claim 24. (NEW) A capacity modulated compressor for an air conditioning or refrigeration system having a refrigerant flow line, comprising:	Abstract; Fig. 1; Summary
a compressor housing comprising a compression chamber,	Fig. 1; Column 1, line 66; Column 2, line 5; Column 2, line 27; Column 2, line 64, etc.
at least one refrigerant injection port operative to pass refrigerant to the compression chamber, and	Abstract; Fig 1; Column 1, lines 26-30; Column 2, lines 1-3; Column 2, line 59 to Column 3, line 9
at least one refrigerant discharge port operative to pass compressed refrigerant from the compression chamber;	Abstract; Fig 1; Column 1, lines 26-30; Column 2, lines 1-3; Column 2, line 59 to Column 3, line 9
a capacity controller operative to generate a control signal corresponding to desired capacity modulation; and	See microprocessor controller 100 in Fig 1; Column 2, lines 22-23
a solenoid valve operatively connected to the controller to receive capacity control signals from the controller and	Abstract; Fig. 1; Column 1, lines 26-30; Column 2, lines 26-48
operative in response to capacity control signals received from the controller to cycle between a fully open position and a fully closed position to modulate compressor capacity.	Column 1, lines 25-27

Terms in Claims

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Claim 25. (NEW) The compressor of
claim 24

wherein the solenoid valve is disposed
in a refrigerant flow line upstream with
respect to refrigerant flow to said at
least one refrigerant injection port.

Claim 26. (NEW) The compressor of
claim 24

wherein the solenoid valve is mounted
to the compressor housing at the
refrigerant injection port.

Claim 27. (NEW) The compressor of
claim 24

wherein the system capacity controller
comprises a microprocessor.

Claim 28. (NEW) The compressor of
claim 24

wherein the solenoid valve in the fully
closed position permits a limited fluid
flow through the refrigerant flow line.

Abstract; Fig. 1; Summary

Abstract; Fig. 1; Summary
Column 2, lines 22-23

Column 2, lines 46-48

Table I

Terms in Claims

Supporting Language in the Specification

Claim 29. (NEW) A capacity modulated compressor comprising:	Abstract; Fig. 1, Summary
a compressor having a suction inlet for supplying suction gas to the compressor;	See compressor 12 in Fig. 1; Column 1, line 66; Column 2, lines 1-5; Column 2, line 27; Column 2, line 64, etc.
a valve provided in the suction gas flow path to the compressor,	Abstract; Fig. 1; Column 1, lines 26-30; Column 2, lines 26-45
the valve being operable between open and closed positions to cyclically allow and prevent flow of suction gas into the compressor;	See Column 1, lines 33-35; Column 2, lines 44-45
a controller for actuating the valve between the open and closed positions,	See microprocessor controller 100 in Fig. 1; Column 2, lines 22-23
the controller being operative to cycle the valve such that its cycle time is shorter than the response time of the system to modulate compressor capacity.	Column 1, lines 32-35; Column 2, lines 41-45
Claim 30. (NEW) The capacity modulated compressor of claim 29 wherein the valve is positioned in close proximity to the compressor.	Abstract; Summary; Fig. 1

Table I

Table I

<u>Terms in Claims</u>	<u>Supporting Language in the Specification</u>
Claim 31. (NEW) The capacity modulated compressor of claim 29 wherein the valve is a bidirectional valve.	Column 1, lines 25-27
Claim 32. (NEW) The capacity modulated compressor of claim 29 wherein the valve is a solenoid valve.	Column 1, lines 25-27

Terms in Claims

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Claim 33. (NEW) A method of modulating the capacity of a compressor in an air conditioning or refrigeration system, comprising	Column 1, lines 32-33; Column 2, lines 41-45
cycling a valve, in fluid communication with the compressor, using a cycle time shorter than the response time of the system to modulate compressor capacity.	Fig. 1; Column 1, lines 32-35; Column 2, lines 41-45
Claim 34. (NEW) The method of claim 33 wherein the valve is a solenoid valve.	Column 1, lines 25-27
Claim 35. (NEW) A method of modulating the capacity of a compressor in a closed refrigerant circulating system, said compressor comprising a compression chamber having a port connected to a refrigerant line of the system through which refrigerant is supplied to the compression chamber, comprising:	Column 1, lines 32-33; Column 2, lines 41-45; Fig. 1
rapidly cycling a solenoid valve disposed in the refrigerant line upstream of said port between its fully open position and its fully closed position to modulate compressor capacity.	Fig. 1; Column 1, lines 25-27

Table II

Terms in Claims

Supporting Language in the Specification

Claim 36. (NEW) The method of claim 35

wherein rapidly cycling said solenoid valve comprises cycling the solenoid valve with a cycling time shorter than the response time of the system to modulate compressor capacity.

Fig. 1; Column 1, lines 25-27; Column 2, lines 38-45

Claim 37. (NEW) The method of claim 35

wherein said cycling controls the percentage of time said solenoid valve is fully open to refrigerant flow therethrough to the compression chamber.

Column 1, lines 32-35; Column 2, lines 41-45

Claim 38. (NEW) The method of claim 35

wherein said cycling is controlled by a microprocessor.

See microprocessor controller 100 in Fig 1; Column 2, lines 22-23

Table II